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# Overview of Tactical Communication Headsets

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**Defence R&D Canada**  
Technical Memorandum  
DRDC Toronto TM 2010-003  
January 2010

Canada



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## Abstract

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This report presents an overview of various in-ear hearing protection and communication systems that are designed for use by the dismounted soldier. Integrated hearing protection headsets (IHPH) offer advanced features such as active noise reduction (ANR) and enhanced hearing capability. However, the electronics that are required to provide such features are challenged in adverse environmental conditions, such as extreme cold. Nonlinear earplugs provide protection from high-level noise while allowing lower-level sounds to pass through without attenuation, making it possible to hear radio communications. However, they do not provide the advanced features that IHPH systems offer. Specific devices including the Nacre QuietPro<sup>®</sup>, Silynx QuietOps<sup>™</sup>, SureFire EP3 Sonic Defender<sup>™</sup> and E-A-R<sup>®</sup> Combat Arms are described and their functionalities are discussed in terms of speech intelligibility and field use.

## Résumé

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Nous présentons ici un aperçu de divers dispositifs intra-auriculaires de communication et de protection de l'ouïe conçus pour les soldats à pied. Les casques d'écoute avec dispositif intégré de protection de l'ouïe (IHPH) offrent des capacités de pointe, entre autres réduction active du bruit (ANR) et amélioration de l'audition. Mais leurs composants électroniques sont vulnérables à de mauvaises conditions météorologiques, p. ex. au froid extrême. Les bouchons d'oreilles non linéaires protègent contre les bruits intenses en laissant passer les sons plus faibles sans affaiblissement, permettant l'écoute de communications radio. Mais ils n'offrent pas les capacités de pointe des systèmes IHPH. Le présent rapport décrit des dispositifs particuliers (Nacre QuietPro<sup>®</sup>, Silynx QuietOps<sup>™</sup>, SureFire EP3 Sonic Defender<sup>™</sup> et E-A-R<sup>®</sup> Combat Arms, entre autres) ainsi que leurs fonctions, et les étudie du point de vue de l'intelligibilité de la parole et de l'utilisation en campagne.

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# Executive summary

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## Overview of Tactical Communication Headsets

**Ann Nakashima; DRDC Toronto TM 2010-003; Defence R&D Canada – Toronto; January 2010.**

**Introduction:** There are various in-ear hearing protection and communication systems that are designed for use by the dismounted soldier. This document provides an overview of several devices that are currently commercially available, in terms of their advantages and disadvantages for use in the field. Two types of hearing protection devices are discussed for use with the personal role radio (PRR). The PRR is normally used with a standard headset that does not offer hearing protection; however, nonlinear earplugs can be worn with the standard headset to provide hearing protection. Nonlinear earplugs use acoustic filters to provide the user with protection from high-level noise while allowing minimal attenuation of desirable, lower-level sounds such as speech. The second type of device is the integrated hearing protection headset (IHPH), which offer simultaneous hearing protection and communication capability. Some IHPH systems offer advanced features such as active noise reduction (ANR) and enhanced hearing capability. These features offer the user protection from both continuous and impulsive noise (e.g., gunfire), as well as control over the volume of sounds from the environment.

**Results:** E-A-R<sup>®</sup> Combat Arms and Surefire EP3 Sonic Defender<sup>®</sup> nonlinear earplugs have been tested both in the laboratory and in the field. Laboratory measurements have found the attenuation provided by the dual-end version of the Combat Arms plug are less than the manufacturer specifications. Field testing of the plugs found that the Combat Arms interfered with some of the headgear (tuque, balaclava), causing it to become dislodged. The EP3 was generally found to stay in place, but some users found it difficult to fit. IHPH devices that have been tested include the Nacre QuietPro<sup>®</sup>, Silynix QuietOps<sup>™</sup> and the Sennheiser SLC 100. The QuietPro<sup>®</sup> and QuietOps<sup>™</sup> were given satisfactory ratings during the field trial for criteria including the clarity of communication, natural hearing capability, ease of use and comfort. However, both devices are battery-powered, and tend to drain quickly in cold weather conditions. The SLC 100 was given lower ratings than the other two IHPH devices, largely because of its lack of durability and the difficulty that users experienced in fitting the earpieces. A laboratory study of speech intelligibility using the QuietPro<sup>®</sup> and QuietOps<sup>™</sup> found that better scores were achieved when using the QuietPro<sup>®</sup>.

**Recommendations:** The QuietPro<sup>®</sup> and QuietOps<sup>™</sup> both have features that can potentially provide improved noise attenuation and increased situational awareness compared to using earplugs alone. However, the use of battery-powered devices increases the burden on the dismounted soldier, who is already carrying other powered devices. The results of the field trial suggest that using the EP3 with the PRR is a good alternative to using an IHPH system. No matter what system is chosen, proper training on the insertion of the earpieces and the correct operation of the device is essential for successful communication in the field.

# Sommaire

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## Overview of Tactical Communication Headsets

**Ann Nakashima; DRDC Toronto TM 2010-003; R & D pour la défense Canada – Toronto; Janvier 2010.**

**Introduction:** Il existe divers dispositifs intra-auriculaires de communication et de protection de l'ouïe conçus pour les soldats à pied. Nous présentons ici un aperçu de plusieurs dispositifs commerciaux du point de vue de leurs avantages et inconvénients en campagne. Deux types de dispositifs de protection de l'ouïe sont étudiés pour utilisation avec le poste radio personnel (PRP). Le PRP s'utilise normalement avec un casque d'écoute ordinaire sans protection de l'ouïe, mais qu'on peut porter avec des bouchons d'oreilles non linéaires. Ces derniers utilisent des filtres acoustiques pour protéger le porteur contre des bruits intenses, mais en atténuant très peu les sons plus faibles et utiles, comme la parole. Le deuxième type de dispositif est le casque d'écoute avec dispositif intégré de protection de l'ouïe (IHPH), qui protège l'ouïe tout en permettant l'écoute des communications. Certains systèmes IHPH offrent des capacités de pointe, entre autres réduction active du bruit (ANR) et amélioration de l'audition. Ces caractéristiques permettent de protéger l'utilisateur contre les bruits continus et impulsifs (p. ex. coups de feu) et de régler le volume des sons ambiants.

**Résultats:** Les bouchons d'oreilles non linéaires E-A-R® Combat Arms et Surefire EP3 Sonic Defender® ont été testés en laboratoire et sur le terrain. Les mesures en laboratoire ont révélé que l'atténuation fournie par la version à double extrémité du bouchon Combat Arms est inférieure aux spécifications du fabricant. Les essais sur le terrain des bouchons ont révélé que le Combat Arms interférait avec certaines coiffures (tuques, passe-montagnes), qui les délogaient. En général, l'EP3 restait bien assujéti, mais certains utilisateurs l'ont trouvé difficile à mettre en place. Les dispositifs IHPH testés comprenaient le Nacre QuietPro®, le Silynx QuietOps™ et le Sennheiser SLC 100. Le QuietPro® et le QuietOps™ ont été jugés satisfaisants lors des essais sur le terrain selon des critères comprenant la clarté des communications, la capacité d'audition naturelle, la facilité d'utilisation et le confort. Toutefois, les deux dispositifs fonctionnaient à piles et avaient tendance à se décharger rapidement par temps froid. Le SLC 100 a été jugé moins satisfaisant que les deux autres dispositifs IHPH, surtout à cause de sa faible durabilité et de la difficulté pour les utilisateurs de mettre en place les oreillettes. Une étude en laboratoire sur l'intelligibilité de la parole avec le QuietPro® et le QuietOps™ a révélé que le QuietPro® obtenait de meilleurs résultats.

**Recommandations:** Le QuietPro® et le QuietOps™ ont tous deux des caractéristiques susceptibles d'améliorer l'atténuation du bruit et la connaissance de la situation à comparer de l'utilisation de bouchons d'oreilles seuls. Toutefois, l'utilisation de dispositifs à piles alourdit la charge du soldat à pied, qui porte déjà d'autres dispositifs à piles. Les résultats de l'essai sur le terrain indiquent que l'EP3 associé avec le PRP offre une bonne solution de rechange au système IHPH. Quel que soit le système choisi, une formation pertinente sur la mise en place des oreillettes et l'utilisation appropriée du dispositif est essentielle à l'efficacité des communications en campagne.



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## **Acknowledgements**

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This research was supported by Defence R&D Canada, Land Partner Group, Command Thrust: Auditory Overload in Land Operations (12oi), Internal Operating Grant.

# 1 Introduction

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Communication between dismounted soldiers in noisy operational environments continues to be a challenge for the Canadian Forces (CF). High levels of continuous and intermittent background noise from sources such as vehicles, weapons and blasts compromise hearing capability, thereby hindering communication and putting the soldiers at risk for permanent hearing loss.

Conventional radio headsets do not provide adequate hearing protection, while conventional hearing protection devices such as passive earmuffs and earplugs reduce situational awareness by impeding face-to-face communication and reducing the ability to localize sounds. In addition, earmuffs are often not compatible with other equipment such as helmets. It is of interest to investigate devices that provide simultaneous hearing protection and communication capability. In this document, such systems will be referred to as Integrated Hearing Protection Headsets (IHPH).

IHPH devices are designed to connect into military radio systems, such as the Personal Role Radio (PRR; Marconi\_Selenia Communications, Genoa, Italy). The PRR is normally used with a headset consisting of a one-sided earpiece and a boom microphone (Figure 1), which does not provide hearing protection. By replacing the standard headset with an IHPH, the soldier is provided with hearing protection, and, with some devices, enhanced hearing capability. Several IHPH systems will be described in this document. In addition, nonlinear earplugs were also investigated. Nonlinear earplugs contain a ridged orifice that serves to attenuate high-level sounds (usually above 110 dBA), while allowing lower-level sounds, such as normal speech, to be heard with minimal attenuation (Berger and Hamery, 2008). This allows the user to maintain situational awareness while being protected from high noise levels. Nonlinear earplugs can be worn with the standard PRR headset to provide a simple, inexpensive way of integrating hearing protection into the communication system. Several of these IHPH systems and nonlinear earplugs have been tested by scientists at Defence Research and Development Canada Toronto (DRDC Toronto; Abel et al., 2007; Abel and Nakashima, 2008; Nakashima and Abel, 2009).

The advantages and disadvantages of several IHPH systems and nonlinear earplugs for use by the dismounted soldiers will be discussed. This document is intended to provide the CF with the information to choose the appropriate devices for procurement and distribution for field use. Note that the emphasis will be placed on the functionality of the devices rather than the amount of noise attenuation that they provide. This is based on the fact that any hearing protection device must be used properly and consistently to give any benefit to the user. A device that is used incorrectly will not protect the user, no matter how much noise attenuation it can potentially provide.



*Figure 1: Personal Role Radio (PRR) with standard headset.*

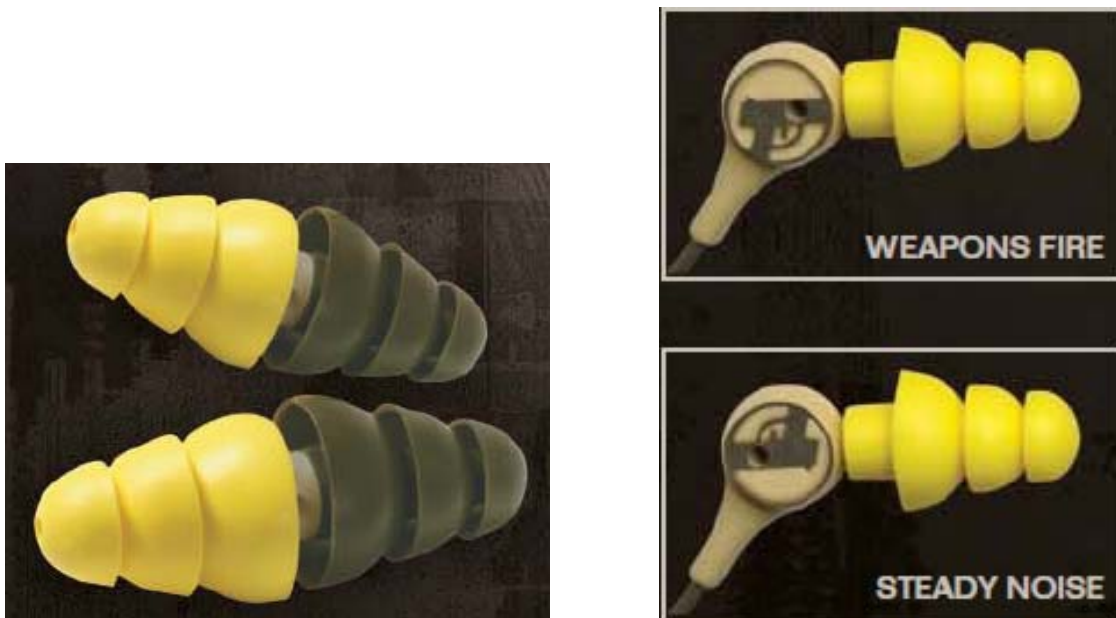
## 2 Description of devices

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### 2.1 Nonlinear earplugs

#### 2.1.1 E-A-R<sup>®</sup> Combat Arms

The E-A-R<sup>®</sup> Combat Arms (AEARO Company, Indianapolis, IN) hearing protector is comprised of two plugs, attached end-to-end (Figure 2). One plug (green) provides conventional, level-independent sound attenuation when inserted into the ear. The other plug (yellow) contains an orifice that allows low-level sounds to pass but impedes high-level impulse noise (e.g., from blasts or gunfire). The Combat Arms is also available as a single-sided plug that uses a rotating dial to open or close the orifice. In the open or weapons fire setting, the plug provides level dependent attenuation, while in the closed or steady noise setting, the plug provides level-dependent attenuation (Figure 2). The manufacturer specifications for attenuation frequencies ranging from 125 to 8000 Hz are given in Table 1. User-fit attenuation measurements have been found to be less than the manufacturer specifications for the dual-end plug (Abel and Lam, 2004), but similar to the specifications for the single-sided plug (Abel and Powlesland, 2010).



*Figure 2: E-A-R<sup>®</sup> Combat Arms earplug. Left: dual-end. Right: single-sided (photos by AEARO Company).*

*Table 1: Manufacturer specified attenuation (standard deviation) of the Combat Arms earplugs.*

	<b>Attenuation (dB)</b>								
<b>Frequency (Hz)</b>	<b>125</b>	<b>250</b>	<b>500</b>	<b>1000</b>	<b>2000</b>	<b>3150</b>	<b>4000</b>	<b>6300</b>	<b>8000</b>
<b>Dual-end Yellow</b>	4.7 (4.0)	4.2 (4.3)	6.0 (5.0)	9.5 (6.7)	16.7 (4.9)	18.6 (5.7)	16.3 (5.8)	16.7 (6.1)	17.2 (6.8)
<b>Dual-end Green</b>	32.7 (5.9)	31.8 (6.1)	33.0 (6.5)	32.0 (5.5)	34.5 (4.1)	37.3 (5.3)	38.9 (6.1)	43.8 (6.7)	43.3 (6.9)
<b>Single-sided Weapons fire</b>	4.1 (2.9)	4.9 (2.9)	10.1 (2.9)	17.0 (3.8)	22.9 (5.1)	29.9 (2.7)	27.4 (3.4)	24.4 (4.0)	24.4 (5.0)
<b>Single-sided Steady-state</b>	32.1 (6.2)	30.6 (5.4)	34.5 (5.6)	31.4 (4.8)	30.8 (4.6)	37.3 (5.9)	36.3 (6.5)	34.1 (4.5)	36.3 (3.8)



### 2.1.2 Surefire Sonic Defender®

The Surefire EP3 Sonic Defender® earplugs (SureFire LLC, Fountain Valley, CA) are designed to fit in the concha of the ear, and are made from a flexible, hypo-allergenic material (Figure 3). They offer level-dependent or conventional sound attenuation through the use of a cap that can be left open or closed to expose or block the orifice. The plugs are available in different sizes, including a larger, 3-flanged version that is designed for larger ear canals (EP4 Sonic Defender Plus®). Noise attenuation values by frequency are not provided by the company on the product data sheet, but it is stated that the EP3 plugs have a Noise Reduction Rating (NRR) of 16 dB and the EP4 plugs have an NRR of 19 dB. Laboratory measurements have shown the attenuation values to range from 4.4 to 27 dB (orifice open) and 14.5 to 31.0 dB (orifice closed) at frequencies between 125 and 8000 Hz (Abel and Nakashima, 2008).



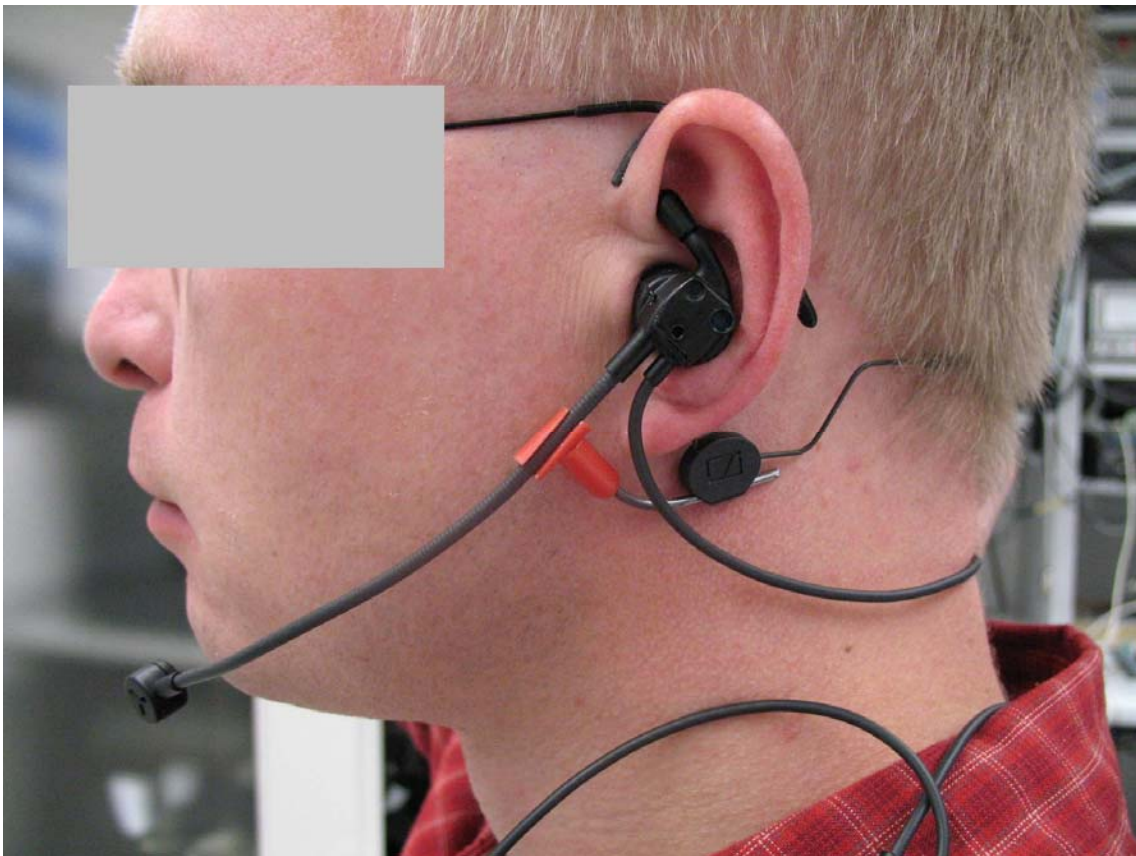
*Figure 3: Surefire EP3 and EP4 Sonic Defender® earplugs.*

Both the Combat Arms (Figure 2) and the Sonic Defender® (Figure 3) earplugs can be worn in the level-dependent mode underneath a communication headset earcup (Figure 1) to allow the user to hear the radio traffic.

## 2.2 Integrated hearing protection headsets

### 2.2.1 Sennheiser SLC 110

The Sennheiser SLC 110 (Figure 4) is a lightweight, in-ear headset that provides passive hearing protection. The headset is held in place by earplugs and concha tips, which are available in different sizes (Figure 5). There are four sizes of concha tips and seven different earplugs: three sizes with flanges and four sizes without flanges. The user can choose the combination of concha tips and plugs that provide the best fit and comfort. The earpieces each have a gate that can be moved to cover or expose the acoustic filter (Figure 6), which works in the same way as the nonlinear earplugs described above. Outgoing communications are delivered through a boom microphone attached to one side of the headset. The microphone can be held in place with the aid of an optional neckband (Figure 4). The SLC 110 plugs directly into the radio and does not require any additional battery power.



*Figure 4: Sennheiser SLC 110 (photo by Sennheiser Government Systems).*

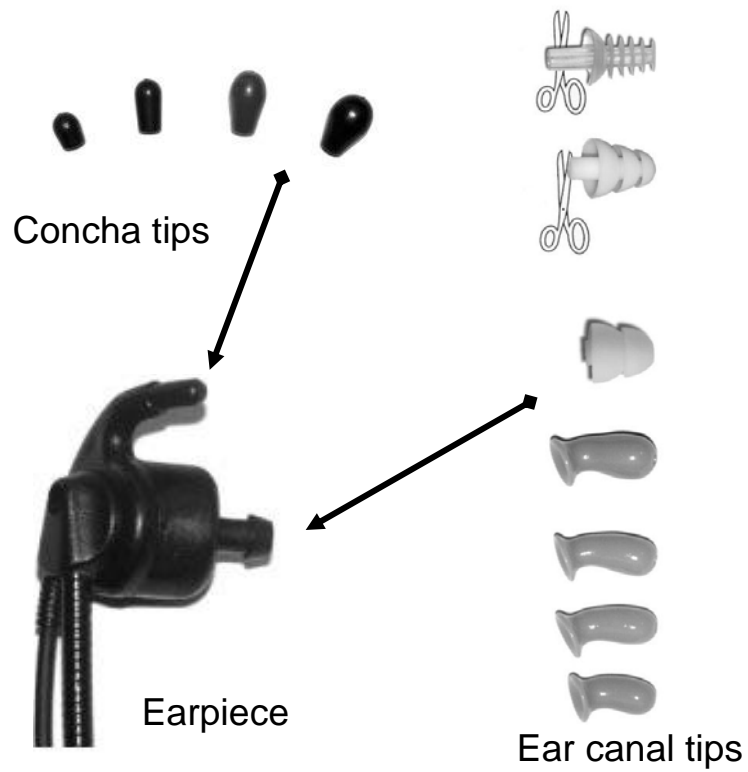


Figure 5: Earpiece of Sennheiser SLC 110 (diagram by Sennheiser Government Systems).

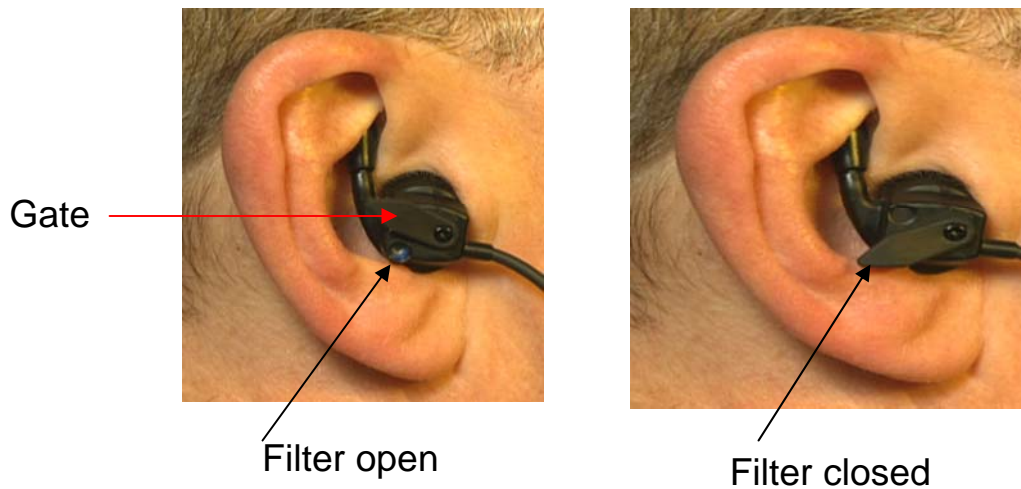


Figure 6: Acoustic filter on the earpiece of the Sennheiser SLC 110 (photos by Sennheiser Government Systems).

### 2.2.2 Nacre QuietPro®

The Nacre QuietPro® is a battery-powered, in-ear device that provides electronic features that are not available with a passive headset (Figure 7). The headset attaches into a unit that encases the electronics. The unit is used to control the radio, and can be used in the push-to-talk (PTT) or continuous communication modes. Two microphones and a speaker are built into the earpieces. The outer microphone captures the ambient sounds from the surroundings. The inner microphone captures the voice of the user, allowing for outgoing communication without the use of a boom microphone. The speaker transmits the incoming radio communication to the ear, mixed with the ambient sounds. It is also used for active noise reduction (ANR) when the ambient noise level exceeds 85 dBA. The user can adjust the speaker volume using two different controls: one for the radio and one for the ambient sounds. Control of the ambient sound level allows the user to decrease the surrounding noise levels, or increase desirable sounds (e.g., somebody talking from a distance). The canal tips (earplugs) that fit onto the earpieces are available in five different sizes. The QuietPro® has a self-check feature that informs the user if the canal tips are inserted properly and are providing an adequate seal.

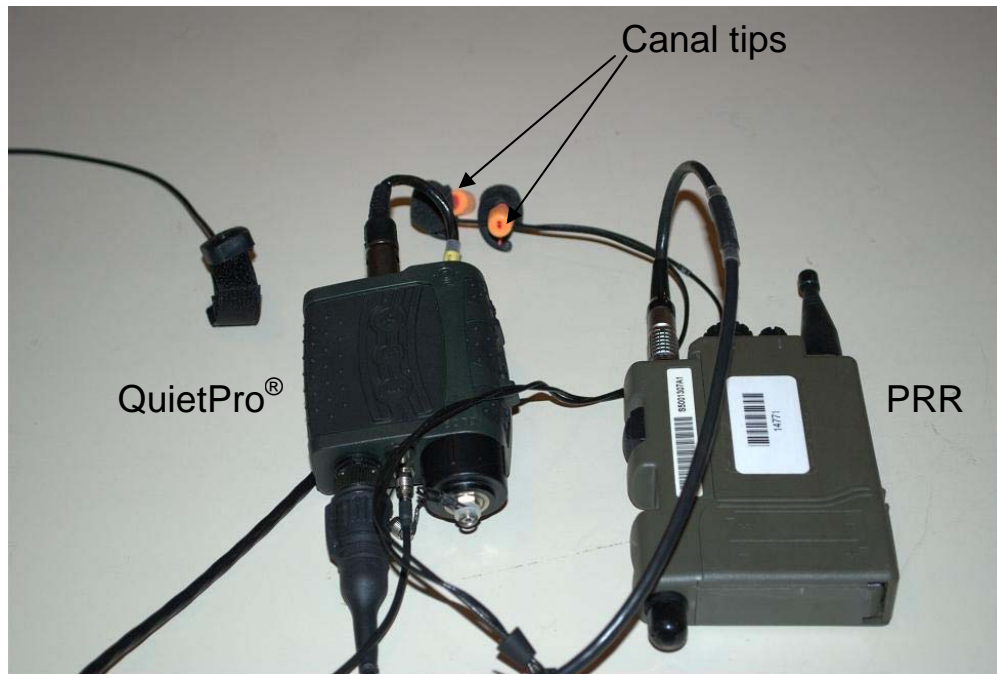


Figure 7: Nacre QuietPro® attached to a Personal Role Radio (PRR).

### 2.2.3 Silynq QuietOps™

The Silynq QuietOps™ (Figure 8), like the QuietPro®, is a battery-powered, in-ear device. It has the same features as the QuietPro® with only minor differences in design. The canal tips are available in five different sizes.



*Figure 8: Silynq QuietOps attached to a Personal Role Radio (PRR).*

#### 2.2.4 Sensear SP1

The Sensear SP1 is a lightweight, battery-powered, in-ear device that enables radio communication while providing hearing protection (Figure 9). Unlike the QuietPro<sup>®</sup> and QuietOps<sup>™</sup>, this device was designed for civilian industrial use rather than military. There are two versions of this device, SP1 and SP1x, with the only difference being that the SP1x provides a bluetooth connection. The ear inserts are available in foam or silicon. The SP1 integrates technologies that are similar in functionality to the QuietPro<sup>®</sup> and QuietOps<sup>™</sup>. Proprietary technology is used for 1) speech enhancement, enabling face-to-face communication in noise and improved use of radio and cell phone communication, and 2) noise suppression, designed to reduce the background noise without affecting the speech signals. The speaker output to the ear is limited to 82 dBA, protecting the user from unsafe radio volumes.



*Figure 9: Sensear SP1x (photo by Sensear Pty Ltd).*

## 2.3 Summary of device features

The features of the non-linear earplugs and IHPH systems described in the previous section are summarized in Table 2.

*Table 2: Summary of the earplug and IHPH system features.*

	<b>E-A-R® Combat Arms</b>	<b>Surefire Sonic Defender® (EP3, EP4)</b>	<b>Sennheiser SLC 110</b>	<b>Nacre QuietPro®</b>	<b>Silynx QuietOps™</b>	<b>Sensear SP1</b>
<b>Type of device</b>	Earplug	Earplug	IHPH	IHPH	IHPH	IHPH
<b>Battery powered</b>	No	No	No	Yes	Yes	Yes
<b>Acoustic filter (passive)</b>	Yes	Yes	Yes	No	No	No
<b>Active noise reduction (ANR)</b>	No	No	No	Yes	Yes	No <sup>1</sup>
<b>Microphone</b>	None	None	Boom	In-ear	In-ear	In-ear
<b>Enhanced hearing (control of ambient listening volume)</b>	No	No	No	Yes	Yes	Yes

<sup>1</sup>Specifications indicate that proprietary technology is used for noise suppression in environments above 85 dBA. It is unknown how the technology compares to ANR.

## 3 Technical review of devices

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### 3.1 Sensear SP1

In November 2008, two DRDC Toronto scientists (Ann Nakashima and Craig Burrell) attended a product demonstration of the Sensear SP1 (Figure 9). The demonstration of the SP1 was presented in an office meeting room environment, using a quasi-white noise signal from a television. While the demonstration showed the basic functionality of the system, it was difficult to judge if the system provided adequate hearing protection and sufficient quality of speech without experimental validation. There did, however, appear to be some noise in the channel during speech transmission. The SP1 was designed for civilian industrial use and was clearly not suitable for military field use in its current design state. The casing of the device and the wires were not sufficiently ruggedized, and the input connection was not compatible with the PRR radio. For these reasons, it was decided that the SP1 would not be purchased for further testing.

### 3.2 Field trial of IHPH devices and nonlinear earplugs

In 2008, a field trial of several IHPH systems was performed by Canadian Forces Environmental Medicine Establishment (CFEME) personnel at the request of Director Land Requirement (DLR) (Drolet and Maceda, 2008). The trial was conducted at Canadian Forces Base (CFB) Petewawa during the winter season. The purpose of the trial was to obtain a human factors analysis for IHPH systems to facilitate the development of a Statement of Requirement (SOR) for the procurement of these devices for dismounted soldiers. Three of the IHPH devices described previously were used in the trial: Nacre QuietPro<sup>®</sup>, Silynx QuietOps<sup>™</sup> and Sennheiser SLC 100. In addition, two types of non-linear earplugs were used with the standard PRR headset: the Surefire EP3 Sonic Defender<sup>®</sup> and the E-A-R<sup>®</sup> Combat Arms (dual-end).

Participants in the field trial rated the devices according to the following criteria:

- Natural hearing capability (can hear ambient sounds)
- Sound localization capability (can locate the source of ambient sounds)
- Compatibility with radio
- Compatibility with other equipment (e.g., helmet, balaclava)
- Sound distortion
- Whisper mode (can transmit and receive whispered speech)
- Feedback (echo or other noise in the communication channel)
- Earpiece fit (does it stay in place?)
- Ease of use
- Comfort
- Do you recommend for future use?

Each of the criteria were rated on a seven-point scale, and space was provided for the trial participants to write comments. The QuietPro<sup>®</sup> was given an average rating of four or better for all of the criteria except for compatibility with the radio. Some of the comments indicated that the radioed speech “flickered,” or sometimes failed to transmit. The QuietOps<sup>™</sup> was given an average rating of five or better on all of the criteria, although some of the comments indicated that



the device was difficult to set up and that the batteries drained quickly. The SLC 110 was given lower ratings than the other IHPH devices, with average ratings of four or lower for whisper mode, earpiece fit, comfort, and recommend for future use. The comments on the SLC 110 indicated that it was difficult to achieve a proper fit with the concha tips, and that the weight of the boom microphone caused the earpiece to fall out. In addition, the piece on the neckband that supported the boom microphone broke easily.

The earplugs were rated according to the following criteria:

- Compatibility with other equipment (e.g., helmet, balaclava)
- Comfort
- Natural hearing capability (can hear ambient sounds)
- Sound localization capability (can locate the source of ambient sounds)
- Ease of insertion
- Earpiece fit (does it stay in place?)
- Feedback (echo or other noise in the communication channel)
- Do you recommend for further use?

The EP3 plug was given average ratings of five and above for all of the criteria, and the comments generally indicated that it worked well and stayed in place. However, some users had problems with fitting the plug properly. The Combat Arms plug was given average ratings of four and higher, except for compatibility with equipment. The users stated that the plug interfered with the tuque and balaclava, causing the plug fall out. As a result, repeated insertion of the plug caused irritation in the ear canals of some users.

The weather conditions during the field trial (as low as -20°C) raised special concerns for the design of communication and hearing protection devices. In particular, the devices must be compatible with cold weather gear (e.g., balaclava, tuque) and powered devices (i.e., batteries) must be able to function at low temperatures. These issues caused problems for the Combat Arms plug, which interfered with the cold weather headgear, and the QuietOps™, because the battery tended to drain quickly. Regardless of weather conditions, the device must be rugged enough for field use. The SLC 110 had pieces supporting the boom microphone that broke during the trial.

Overall, it was recommended that: 1) the QuietPro® and QuietOps™ be further tested to develop an SOR for procurement of IHPH devices, 2) the EP3 and standard PRR headset should be used as an interim solution and 3) the Combat Arms (dual-end) and standard PRR headset should be worn by users who have problems fitting the EP3.

### 3.3 Laboratory testing of QuietPro® and QuietOps™

Following on the results of the field trial, the quality of radio communications using the QuietPro® and QuietOps™ with the PRR radio was evaluated in the laboratory using speech intelligibility tests (Nakashima and Abel, 2009). Using the Modified Rhyme Test (MRT) and the Speech Perception in Noise test (SPIN), pairs of subjects communicated word and sentence lists through the radio in the presence of 75 dBA background noise. In addition, the subjects were asked to rate the systems on a seven-point scale on the following criteria:

- Overall ease of use
- PTT (push-to-talk) button ease of use
- Earphone/headset comfort
- Speech fidelity (i.e., was the speech distorted?)
- Clarity of communication (i.e., was the channel noisy?)
- Continuity of communication (i.e., was the speech broken?)
- Annoyance due to ambient noise
- Overall rating

The average ratings for each of the criteria were added to obtain user acceptance scores for each device. Significantly higher scores on both the MRT and SPIN were obtained while using the QuietPro® (approximately 83% and 87%) than while using the QuietOps™ (approximately 70% for both tests), suggesting that the QuietPro® provided better speech intelligibility. The QuietPro® was given average ratings of five or better on all of the criteria, for a total user acceptance score of 48.8. The QuietOps™ was given lower average ratings (four or better), for a total score of 35.9. This is in contrast to the field study, where the results suggested that the users had a slight preference for the QuietOps™.

## 4 Summary and Recommendations

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Electronic IHPH systems such as the QuietPro<sup>®</sup> and QuietOps<sup>™</sup> incorporate technologies such as ANR and enhanced hearing capability, which can potentially improve the noise attenuation and increase situational awareness. The in-ear microphones conveniently eliminate the need for a boom microphone, which can break off or interfere with other equipment. Based on the studies that have been summarized in this document, both devices are acceptable for field use and differences between them are based on personal preference. Higher scores for speech intelligibility were obtained in the laboratory with the QuietPro<sup>®</sup>, which gives it an advantage over the QuietOps<sup>™</sup>. However, this is provided that it functions well in the field conditions, which was not always in case in the cold-weather field trial. The Sensear SP1 is not recommended because it is not sufficiently rugged for military field use.

It should be noted that battery-powered devices add an extra burden to the dismounted soldier, who is already carrying extra batteries for other powered devices. Thus, it is important to consider hearing protection devices that do not require power, even though they cannot provide advanced features such as enhanced hearing and ANR. The results of the field trial suggest that the EP3 is potentially a good type of earplug to wear with the standard PRR headset, provided that the user is able to obtain a good fit. The SLC 110 is not a good choice because of its lack of durability in the field. The dual-end Combat Arms plug was found to be incompatible with cold-weather headgear. It is unknown if the single-sided Combat Arms plug would cause similar problems.

This document has focused on the functionality of IHPH systems and nonlinear earplugs rather than the amount of noise attenuation that they provide. The noise attenuation that is measured in the laboratory can be quite different from the attenuation that is achieved by user-fit devices in practice, and can vary greatly between users (Neitzel and Seixas, 2005; Voix and Laville, 2009). In reality, if a device does not work well, is uncomfortable or interferes with other equipment, the soldiers will not use it. Additionally, if they are not properly trained on how to insert the earplugs and use the devices properly, the benefits of the technology will not be realized. Proper training and follow-up on correct usage are essential for success.

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## List of symbols/abbreviations/acronyms/initialisms

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ANR	Active Noise Reduction
CFB	Canadian Forces Base
CFEME	Canadian Forces Environmental Medicine Establishment
DLR	Defence Land Requirement
DRDC	Defence Research & Development Canada
IHPH	Integrated Hearing Protector Headset
NRR	Noise Reduction Rating
PRR	Personal Role Radio
SOR	Statement of Requirement

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(U) This report presents an overview of various in-ear hearing protection and communication systems that are designed for use by the dismounted soldier. Integrated hearing protection headsets (IHPH) offer advanced features such as active noise reduction (ANR) and enhanced hearing capability. However, the electronics that are required to provide such features are challenged in adverse environmental conditions, such as extreme cold. Nonlinear earplugs provide protection from high-level noise while allowing lower-level sounds to pass through without attenuation, making it possible to hear radio communications. However, they do not provide the advanced features that IHPH systems offer. Specific devices including the Nacre QuietPro®, Silyn timer QuietOps™, SureFire EP3 Sonic Defender™ and E-A-R® Combat Arms are described and their functionalities are discussed in terms of speech intelligibility and field use.

(U) Nous présentons ici un aperçu de divers dispositifs intra-auriculaires de communication et de protection de l'ouïe conçus pour les soldats à pied. Les casques d'écoute avec dispositif intégré de protection de l'ouïe (IHPH) offrent des capacités de pointe, entre autres réduction active du bruit (ANR) et amélioration de l'audition. Mais leurs composants électroniques sont vulnérables à de mauvaises conditions météorologiques, p. ex. au froid extrême. Les bouchons d'oreilles non linéaires protègent contre les bruits intenses en laissant passer les sons plus faibles sans affaiblissement, permettant l'écoute de communications radio. Mais ils n'offrent pas les capacités de pointe des systèmes IHPH. Le présent rapport décrit des dispositifs particuliers (Nacre QuietPro®, Silyn timer QuietOps™, SureFire EP3 Sonic Defender™ et E-A-R® Combat Arms, entre autres) ainsi que leurs fonctions, et les étudie du point de vue de l'intelligibilité de la parole et de l'utilisation en campagne.

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(U) Hearing protection, tactical communication

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